



N73-33040

SCIENTIFIC AND TECHNICAL SERVICES  
DIRECTED TOWARD THE DEVELOPMENT OF  
PLANETARY QUARANTINE MEASURES FOR AUTOMATED SPACECRAFT

Second Quarterly Report  
Contract NASw - 2503

For  
National Aeronautics and Space Administration  
Planetary Quarantine Office  
Washington, D. C. 20546

October 10, 1973

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## INTRODUCTION

This report constitutes the Second Quarterly Progress Report summarizing work performed through September 30, 1973 under contract NASw-2503.

The material is organized in two parts; viz., a section describing the work performed on each of the twelve tasks and an analysis section presenting details on analysis performed during the reporting period.

## TASK PROGRESS

Progress during the reporting period of July 1, 1973 — September 30, 1973 is described in this section for the twelve contract tasks.

### Task 1. Evaluation of the Impact of Changes in Planetary Quarantine Requirements

Under this task, evaluations are conducted to support the justification and establishment of planetary quarantine requirements and parameters and to estimate their implications upon flight projects.

In the compilation of parameter specifications for issuance in the forthcoming PQ Specification Book, thirty (30) separate parameters have been reviewed for currency and adequacy. Space survival parameters are being reviewed in the light of data reported from JPL tests and other pertinent research. The effect of preliminary data describing the heat resistance of naturally-occurring microorganisms on sterilization requirements was analyzed and a possible methodology for the assessment of these data was developed. A review of this work is provided in the Analysis section.

Parameter review and assessment is continuing and will culminate in the issuance of a document containing specification sheets for each parameter approved by the PQO for use or for planning purposes by unmanned planetary space programs. This document is planned for issue under NASA cognizance during the next reporting period.



Assistance has been provided to members of Stanford Research Institute in their review of the evaluation and application of P(g). In particular, we provided background and historical material and discussed the evolution of the PQ requirements model during a visit to Exotech by SRI personnel on August 6-7, 1973.

## Task 2. Maintain and Operate the Planetary Quarantine Document System

The Quarantine Document System (QDS) is an indexed file of material pertinent to the review of flight project quarantine plans and operations. This task covers the operation, maintenance and updating of the system.

During the reporting period the collection experienced continued growth and use. The collection now numbers 720 documents.

Among the retrievals conducted during this reporting period, in support of the PQO, are:

- Material relating to agreements made with the VPO regarding Viking bioassays
- COSPAR's position on sample return and back contamination
- Schemes and values used for  $P_c$  allocation to flight projects
- Transmittal letters for Post Launch Analysis reports for past missions
- References to tests of the sensitivity of microorganisms to radiation applied after heat treatment
- Decisions and policy actions bearing on outer planet quarantine
- Background discussions and actions relating to sample return and back contamination strategies and missions
- Material relating to the review of Viking Program PQ Plan, the VLC Sterilization Plan and the Viking Microbiological Assay Plan

Additional summarizations in special binders have been provided on:

- Planetary Quarantine Issues Relating to Sample Return Missions, and
- PQ Policies, Decisions and Actions for Outer Planet Missions



### Task 3. Microbial Contamination Logs

The Committee on Space Research (COSPAR) has asked each launching nation to supply it with information on planetary missions for the maintenance of a contamination log. For record purposes and to establish the allocation of contamination probabilities to future missions to planets of biological interest, the PQO requires a log of missions of all nations insofar as data are available. This task supports the preparation and maintenance of these logs.

Pertinent PQ data is being compiled from the flights of Pioneer 10 and 11 and will be used to update the Jupiter Contamination Log and create a Saturn Contamination Log as appropriate.

Reports on the progress of the Mariner 9 mission are being reviewed for possible changes in the estimated probability of contamination reported in the last Mars Log.

### Task 4. Maintenance of Allocation Bank

The United States, the Union of Soviet Socialist Republics and other launching nations are allotted portions of the total probability of contamination of each planet and provided with estimates of the total number of missions expected to be flown. From these data, the Planetary Quarantine Officer makes pre-launch allocations of the probability of contamination that may be used by each flight project. The purpose of this task is to assist the Planetary Quarantine Officer in making the optimum allocation, consistent with NASA and COSPAR policies, to each United States mission.

During this reporting period, a review of the status of mission sub-allocations was performed. QDS references summarizing review results are shown in Table 1.

In addition, a P(N) value for the Saturn encounter option of the Pioneer 11 mission was developed and recommended for application. Allocation methods for other outer planet missions are under review.

Reports of the Mariner 9, Pioneer 10 and Pioneer 11 flights are being monitored for possible effects on the allocation banks for the respective planets. Changes are being reflected on the NASA PQ Status Board as they occur.

### Task 5. Creation and Maintenance of List of Approved Parameters

Uniformity of policy and facilitation of document review can be effected through a listing of parameters and requirements employed by flight

TABLE I.  
P(N)-PROBABILITY OF CONTAMINATION ALLOCATION STATUS

PLANET	MISSION	DOCUMENTATION	REFERENCE
MARS	Sub-allocation Schemes for All Martian Missions	PQ-109	(Allocates to 70 landers and 30 non-landers)
		PQ-87	(Allocates to 18 future U.S. flights)
		PQ-369	(Reallocates recoverable allocations)
	Mariner Mars '64		(Governed by NASA-developed specifications)
	Mariner Mars '69		(Governed by specification deriving from COSPAR 26.5)
	Mariner Mars '71	PQ-109	(Recommends to SL an allocation of $30 \times 10^{-6}$ )
	Viking '75	PQ-41	(Authorizes use of $71 \times 10^{-6}$ )
		PQ-109	(Recommends to SL an allocation of $31.4 \times 10^{-6}$ )
		PQ-40	(Authorizes use of $72 \times 10^{-6}$ )
		PQ-561	(Authorizes use of $100 \times 10^{-6}$ )
VENUS	Suballocation Schemes	PQ-53	(Implies a methodology)
	Mariner Venus '62		(no evidence of requirement)
	Mariner Venus '67		(Governed by specification derived from COSPAR 26.5)
	Mariner Venus/Mercury '73	PQ-53	(Authorizes use of $70 \times 10^{-6}$ )
JUPITER	Suballocation Schemes	PQ-71	(Allocates to 35 landers and 15 non-landers)
	Pioneer F and G	PQ-71	(Recommends $64 \times 10^{-6}$ for F and G)
		PQ-49	(Authorizes $64 \times 10^{-6}$ )



projects in validating compliance with basic PQ constraints. This task covers the preparation of such a listing with definitions, references to pertinent research, and approved numerical values or ranges.

The major development under this task has been the design and preparation of the PQ Specification Book referred to in the report on Task 1. This document and its intended utilization were described by Mr. Edward J. Bacon at the AIBS Spacecraft Sterilization Seminar in Denver on July 11, 1973.

Details have now been completed and the individual parameter specification sheets are in preparation. A distribution list of recipients of this controlled document is nearing completion.

The book is planned to be issued during the next reporting period.

#### Task 6. Preparation of Technical Information Memo

The Planetary Quarantine Technical Information Memo (TIM) is a brief, informal newsletter containing summaries of research results of note, meetings, significant travel plans, policy decisions, changes in personnel, initiation of new research tasks, and management deadlines.

Two editions were issued during this reporting period:

7/6/73 — Listed planned presentations at COSPAR, Konstanz, FRG; reported on Stockholm symposium on automated biology methods; and discussed change in KSC-USPHS lab support.

8/23/73 — Reported on status of KSC-teflon tests, on LSC Viking Meetings at TRW, and on the new JPL role in directing the KSC-assay lab operations.

#### Task 7. Evaluation of Flight Project Quarantine Plans

This task provides support to the PQO in the review and approval of flight project documentation demonstrating compliance with PQ requirements.

During this reporting period, the following documents were reviewed with results as reported:

1. PQ-715 — Pioneer 11 Post Launch Analysis Report, review completed 7/22/73



2. PQ-714 – MVM '73 Pre-Launch Analysis Report
3. PQ-713 – MJS '77 PQ Plan
4. PQ-716 – Preliminary Copy, Viking 75 Program PQ Plan, M75-145-0, submitted 8/1/73
5. PQ-717 – Preliminary Copy, Viking 75 Program Lander Capsule Sterilization Plan, M75-147, submitted 8/1/73
6. PQ-685 – Preliminary Copy, Viking 75 Program Microbiological Assay and Monitoring Plan, M75-148-0, submitted 8/1/73

The Pioneer 11 Postlaunch Analysis report was approved and transmitted 8/7/73 to the SSB for referral to COSPAR.

The Pioneer Project has been requested by the PQO to supplement its Postlaunch Analysis to include the effects of the proposed option to encounter the planet Saturn. To assist in this analysis, the PQO has issued tentative working values for  $P(g)$  for Saturn and its satellites and for an allocation of  $P_c$  for this leg of the mission. The further analysis of this option was discussed during a meeting at ARC on August 23, 1973 attended by the PQO, members of the Pioneer project and Exotech.

The MVM '73 mission has been certified for launch. Pertinent documentation is in process. The current planned launch date is November 3, 1973.

The MJS '77 PQ Plan has been approved. (See PQ-713)

A Viking '75 Program PQ Plan review meeting was held in Washington, D.C. on September 25-26, 1973. Meeting attendees were:

Professor R. Bond, Chariman	AIBS, PQP
Dr. L.B. Hall	PQO
Mr. L. Daspit (Viking Project)	NASA/Langley
Dr. J.A. Stern	Bionetics Corp.
Mr. M.J. Landry	Bionetics Corp.
Mr. S. Schalkowsky	Exotech
Mr. R.P. Wolfson	Exotech

Preliminary drafts of the following documents were reviewed in detail:

Viking '75 Program PQ Plan, M75-149-0  
Viking '75 Program Lander Capsule Sterilization Plan, M75-147  
Viking '75 Program Microbiological Assay and Monitoring Plan, M75-148-0



Working agreements were reached on all items. A second meeting, to review agreed on changes to the plans, is scheduled for October 4 in Langley, Virginia.

#### Task 8. Supporting Analysis of Planetary Quarantine Sterilization Parameters

This task includes analyses and evaluations intended to support the interpretation of research results and to facilitate the quantification of PQ requirements.

The principle task undertaken during this period was a preliminary review of the impact of KSC heat inactivation tests of naturally occurring microorganisms. Of primary concern was the effect of these test results upon sterilization cycle requirements. We performed a systematic assessment of preliminary KSC data, including the recently completed low humidity runs, and determined what sterilization requirements were affected and to what degree. A method was evolved for the incorporation of the KSC test results in the design of a sterilization cycle. In addition, the need for further research was identified.

The results of this assessment were presented by Mr. P. Stabekis at the AIBS Spacecraft Sterilization Seminar at Denver, Colorado on July 11, 1973 and further analyzed by Mr. S. Schalkowsky for members of the AIBS PQP at Denver on July 13, 1973. Mr. Schalkowsky's presentation is included in the Analysis Section.

A second effort initiated under this task is the analysis of the Viking biological experiment microbial nutrient as a potential source of planetary contamination. The possibility that the nutrient, in its designed operational mode, in a post-experiment configuration or in a failure condition, may accidentally become contaminated and subsequently release viable microorganisms to the surface or atmosphere of Mars, in a way to cause planetary contamination, is being studied.

#### Task 9. Preparation of Technical Presentations

This task relates to the preparation of written and graphic material as required by the PQO for publications, briefings, speeches on PQ subjects and communications to individuals and groups.

During the reporting period the following support was provided under this task:

- o Support to the PQO in preparation of a paper on control aspects of PQ for publication in a future issue of Critical Reviews in Environmental Control produced by the Chemical Rubber Company.





- o Visual material on quarantine concerns in sample return missions for presentation to the Administrator, Office of Space Science in September 1973.
- o Methodology for Analyzing Heat Inactivation Testing of Naturally Occurring Organisms, presented by P. Stabekis to AIBS Spacecraft and Sterilization Seminar, Denver, July 11, 1973.
- o PQ Parameter Evaluation Control and Information Dissemination, presented by E.J. Bacon to AIBS Spacecraft Sterilization Seminar, Denver, July 11, 1973.
- o Implications of New Information on Sterilization, presented by S. Schalkowsky to AIBS PQ Panel, Denver, July 13, 1973.

#### Task 10. Technical Support at Meetings

The PQO has frequent need for technical support relative to meetings of the LSC, SSB, COSPAR, flight project PQ working groups and experimenters' conferences. This task covers the provision of this support on request of the PQO and includes the compilation of analytical data, attendance at specified meetings and presentations as requested.

Such support was provided for the following meetings and conferences:

July 11-12	AIBS Spacecraft Sterilization Seminar	Denver, Colorado
July 12-13	AIBS Planetary Quarantine Panel	Denver, Colorado
Aug. 15	Viking Biology Instrumentation Meeting	Hampton, Virginia
Aug. 21	Viking Biology Instrumentation Meeting	TRW - Los Angeles
Aug. 22	Back Contamination Meeting	JPL - Pasadena
Aug. 23	Pioneer 10 and 11	NASA/Ames - Moffet Field, Calif.
Sept. 18-20	Viking Lander Critical Design Review	Denver, Colorado
Sept. 25-26	Viking PQ Plans - Review Meeting	Washington, D.C.



## Task 11. Support of Technology Transfer

This task supports the transfer of PQ technology between Centers, between Centers and Projects, between NASA and its contractors and between NASA and the scientific community. It covers such activities as the preparation of technical presentations and technical support at meetings (subjects of Tasks 9 and 10), as well as the dissemination of PQ technology information upon referral of inquiries by the PQO and the preparation of material for the AIBS PQ Panel.

Requests for PQ information have been received from PQO staff and the GWUBSCP and have been filled by retrievals from the QDS. In addition, assistance was provided in suggesting items for consideration at the PQP meeting of July 12 - 13 in Denver.

## Task 12. Integrated Resumes of NASA Research

This task is intended to provide resumes of research combining all relevant data from all sources on a specific subject.

No specific assignments have been made under this task; however, several important research areas have been reviewed and pertinent data compiled or reported verbally. These areas include:

- o Back contamination and sample return
- o PQ needs for outer planet missions

## ANALYSIS

### Implications of New Information on Sterilization Requirements

The effect of preliminary wild organism data and other new information on sterilization requirements was analyzed to:

1. show a possible methodology for the assessment of these data, and
2. identify further activity required for incorporating the relevant new information.

The parameters examined are the D values for surface, mated and buried microbial burden and the probability of growth,  $P(g)$ , for Mars.



The effect of the preliminary Cape results on the three  $D$  values were assessed through the use of the crossover point concept (see attached charts for definition). Alternative methods of approach were presented and discussed to help define needed additional research.

Potential new information bearing on the probability of growth estimation was identified and the question was voiced as to whether a reevaluation of  $P(g)$  is warranted.

The following figures, descriptive of the above analysis, were presented by S. Schalkowsky to PQP at Denver on July 13, 1973.

**SUBJECT:** EFFECT OF PRELIMINARY WILD ORGANISM  
DATA AND OTHER NEW INFORMATION ON  
STERILIZATION REQUIREMENTS.

**OBJECTIVE:** TO ASSESS POSSIBLE AREAS OF ACTIVITY  
REQUIRED TO INCORPORATE RELEVANT  
NEW INFORMATION.

**APPROACH:** SYSTEMATIC LOOK AT WHAT PRESENT  
REQUIREMENTS ARE AFFECTED, AND HOW.

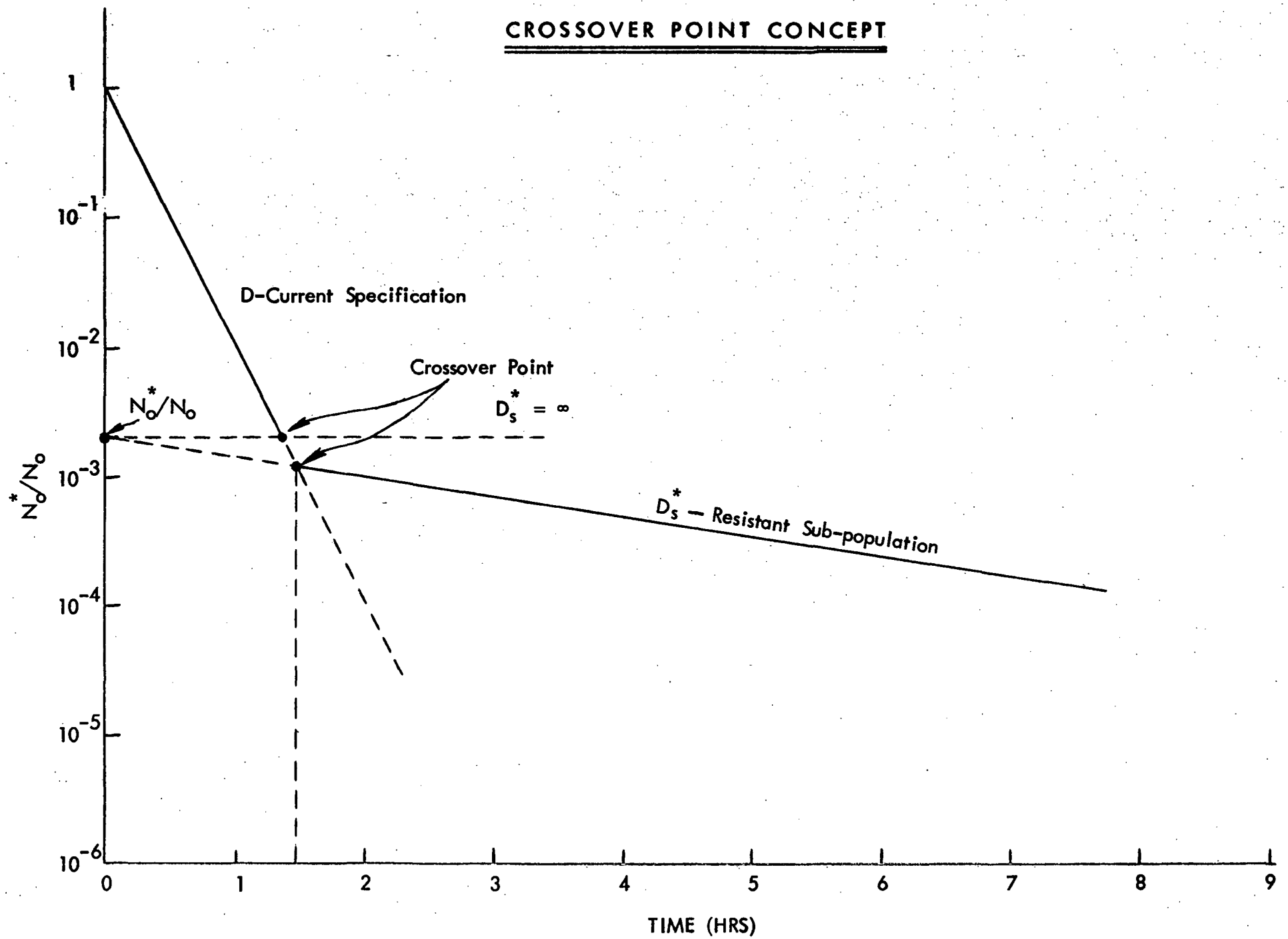
## BACKGROUND

- HEAT RESISTANCE TESTS OF NATURALLY OCCURRING MICROORGANISMS SHOW A HIGHLY RESISTANT SUB-POPULATION
- CURRENT REQUIREMENTS ALLOW FOR RELEASE OF LIMITED NUMBER OF VIABLE ORGANISMS ON PLANET SURFACE

# SURVEY OF SPECIFICATIONS

ITEM	APPLICABLE DOCUMENT	PRESENT SPECIFICATION	NEW DATA
Resistance of Surface Microorganisms $D_S, Z_S$	NHB 8020.12 Para. 2.2.4.2	$D_S^{125^\circ} = 0.5 \text{ hrs } Z = 21^\circ \text{C}$ Based on <u>B. Subtilis</u> Data	$D_S^{125^\circ} = 6.5$ (preliminary) for most resistant 0.25% sub-population, $Z = 21^\circ \text{C}$
Resistance of Mated Microorganisms $D_M, Z_M$	NHB 8020.12 Para. 2.2.4.2	$D_M^{125^\circ} = 1.0 \text{ hrs } Z = 21^\circ \text{C}$ Based on <u>B. Subtilis</u> Data	Presence of resistant sub-population In "naturally occurring environments"
Resistance of Buried Microorganisms $D_B, Z_B$	NHB 8020.12 Para. 2.2.4.2	$D_B^{125^\circ} = 5.0 \text{ hrs } Z = 21^\circ \text{C}$ Based on <u>B. Subtilis</u> Data	Presence of resistant sub-population in "naturally occurring environments"
Microbial Density in Materials $\bar{d}_v$	Parameter Specification Sheet	130 Spores/cm <sup>3</sup>	Presence of resistant sub-population in "naturally occurring environments"
Probability of Microbial Proliferation on Mars $P(g)$	Parameter Specification Sheet	$P(g) = 10^{-6}$ Based on Woods Hole evaluation in July 1970	Survivors are of one type? (Resistant sub-population) New analytical approach (SRI) ? Mariner 9 data.
Counting	NHB 8020.12 Para. 2.2.4.4	Primarily Considering Aerobes	Resistant sub-population characteristics
Probability of Surviving Transit Environments $P_{st}, P_{uv}, P_{vt}$	Parameter Specification Sheet	See Specification Sheets	No new applicable data.
Probability of Release Parameters	Parameter Specification Sheets	See Specification Sheets	No new applicable data

# CROSSOVER POINT CONCEPT

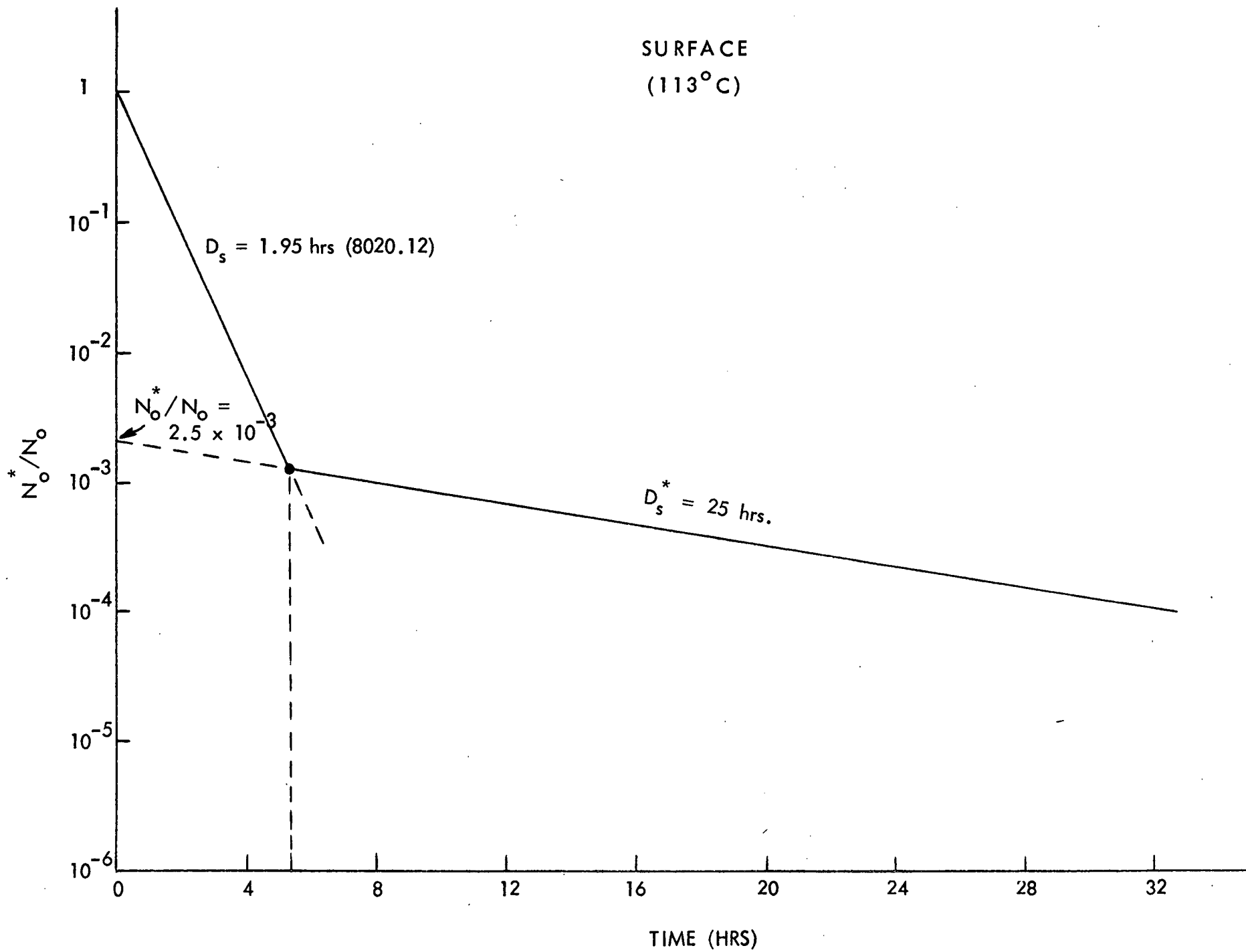


### CROSSOVER POINT CONCEPT

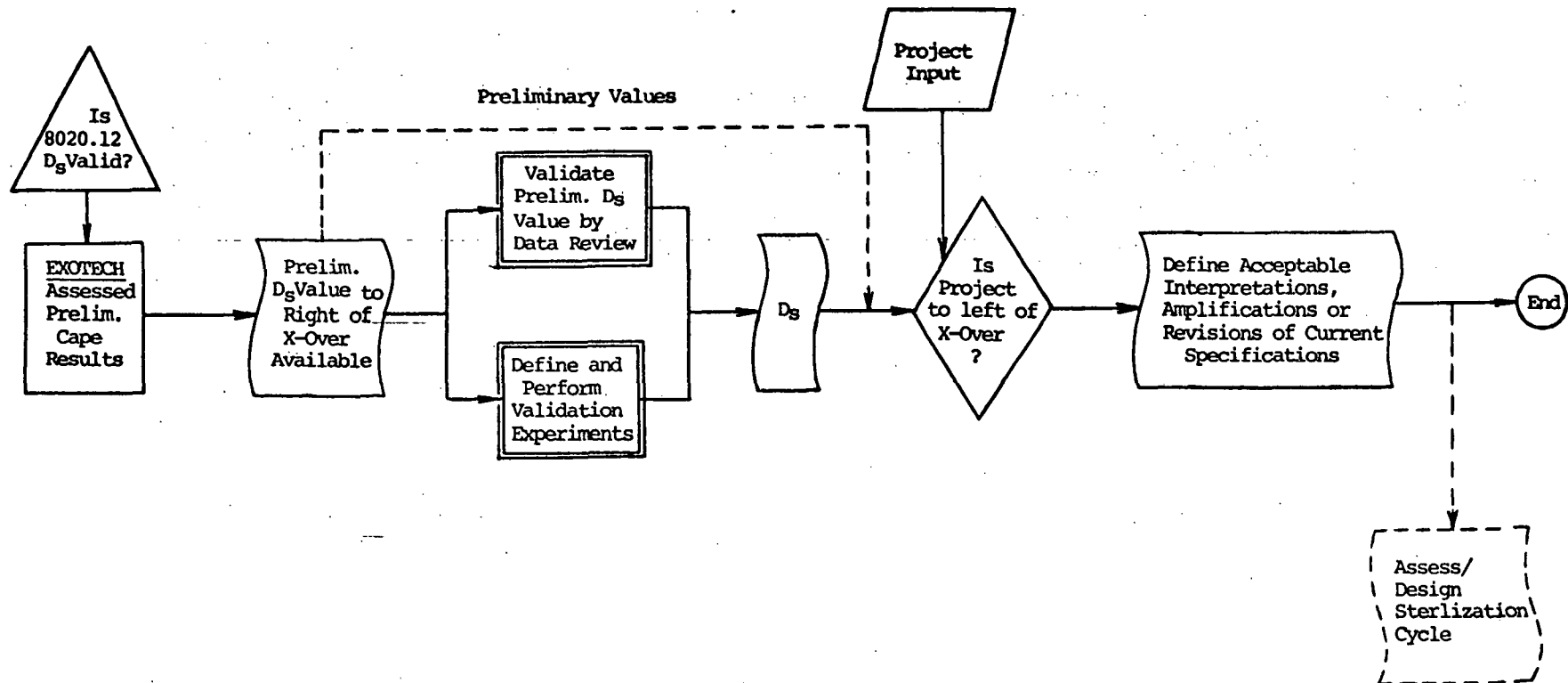
CROSSOVER POINT DEFINED BY ASSOCIATED NUMBER OF DECADES REDUCTION OR BY TIME AT TEMPERATURE DURING STERILIZATION CYCLE.

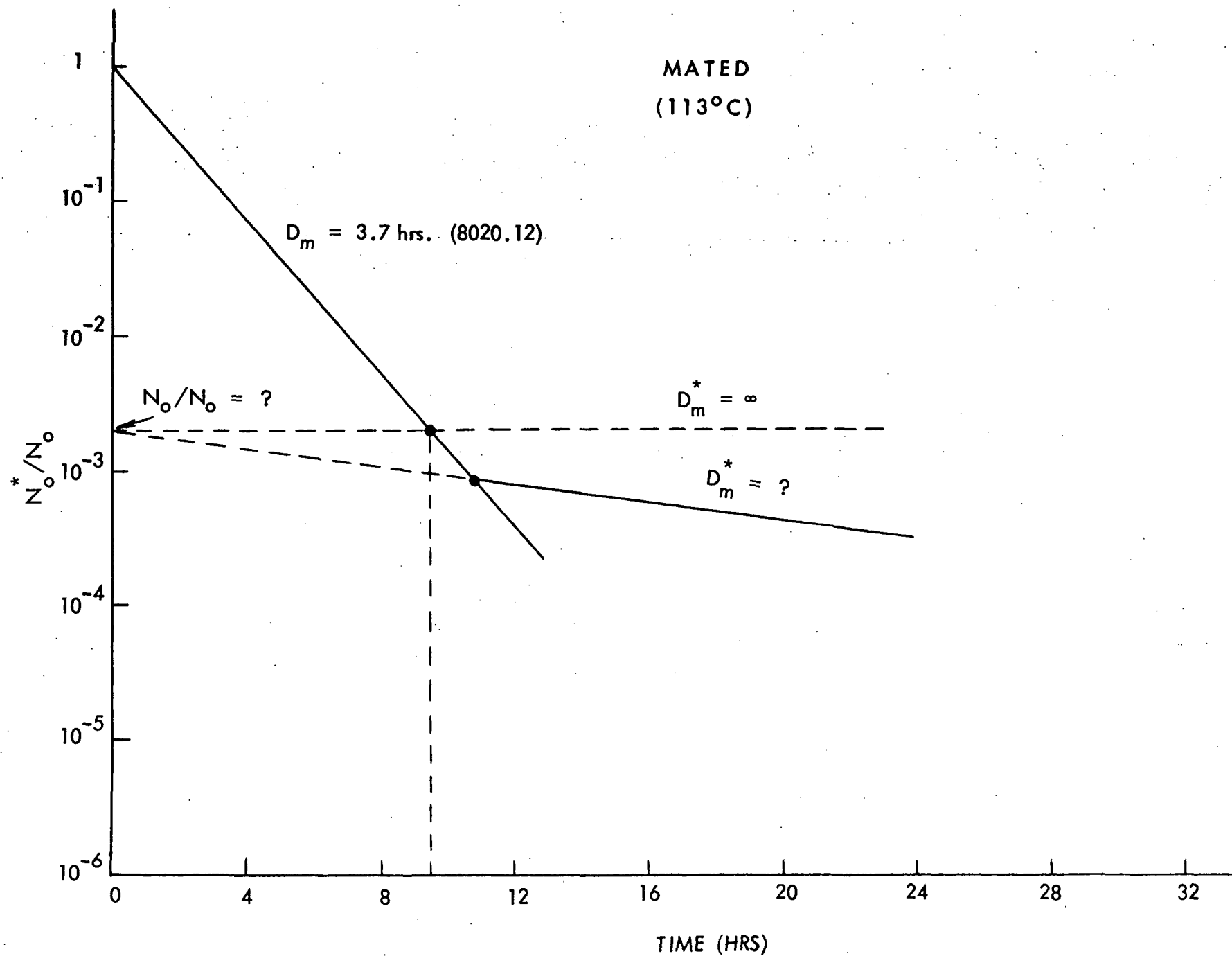
- o IF STERILIZATION CYCLE IS TO LEFT OF CROSSOVER POINT, CURRENT NHB 8020.12 REQUIREMENTS ARE CONSERVATIVELY MET.
- o IF STERILIZATION CYCLE IS TO RIGHT OF CROSSOVER POINT, CURRENT REQUIREMENTS NEED TO BE REVIEWED.



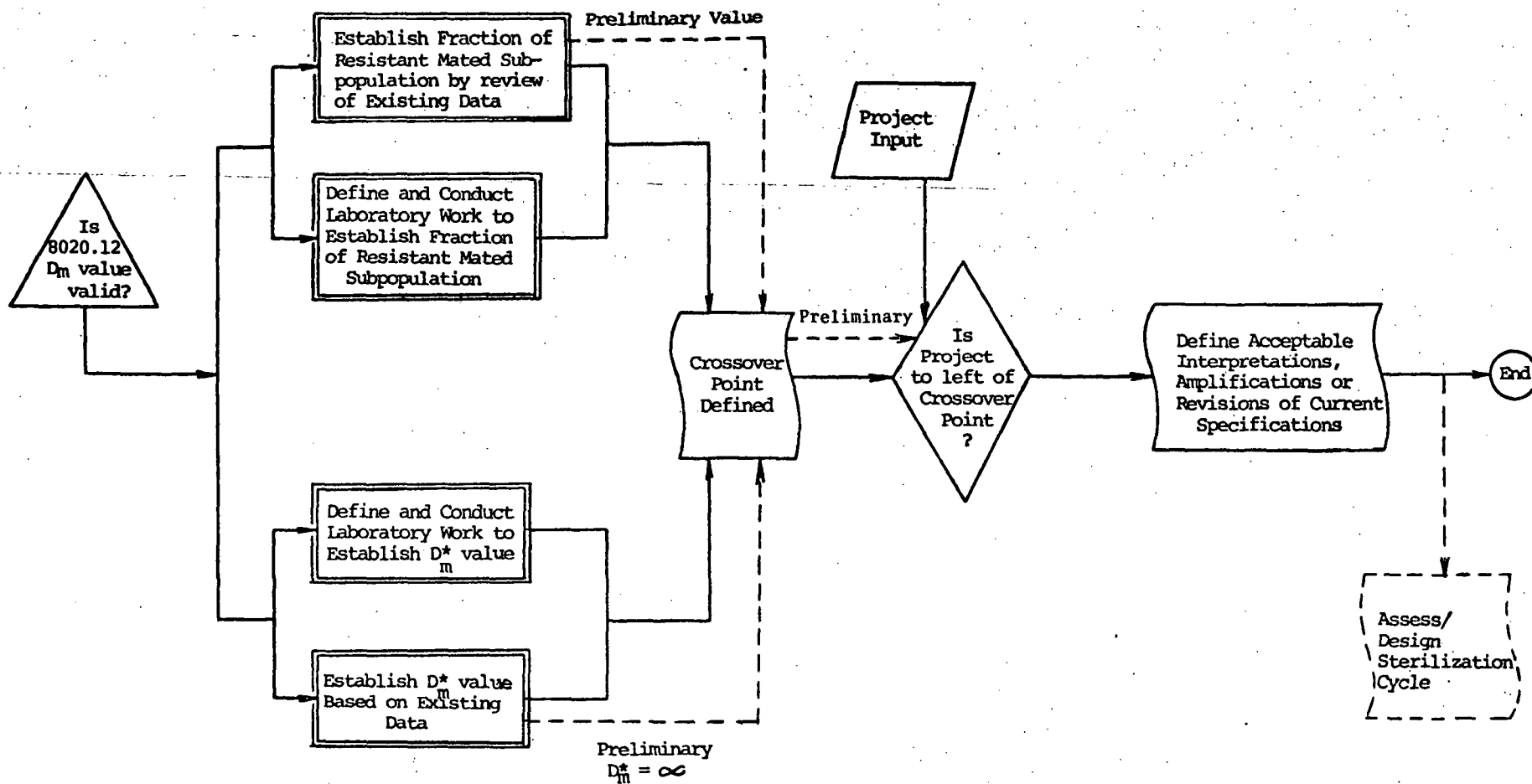


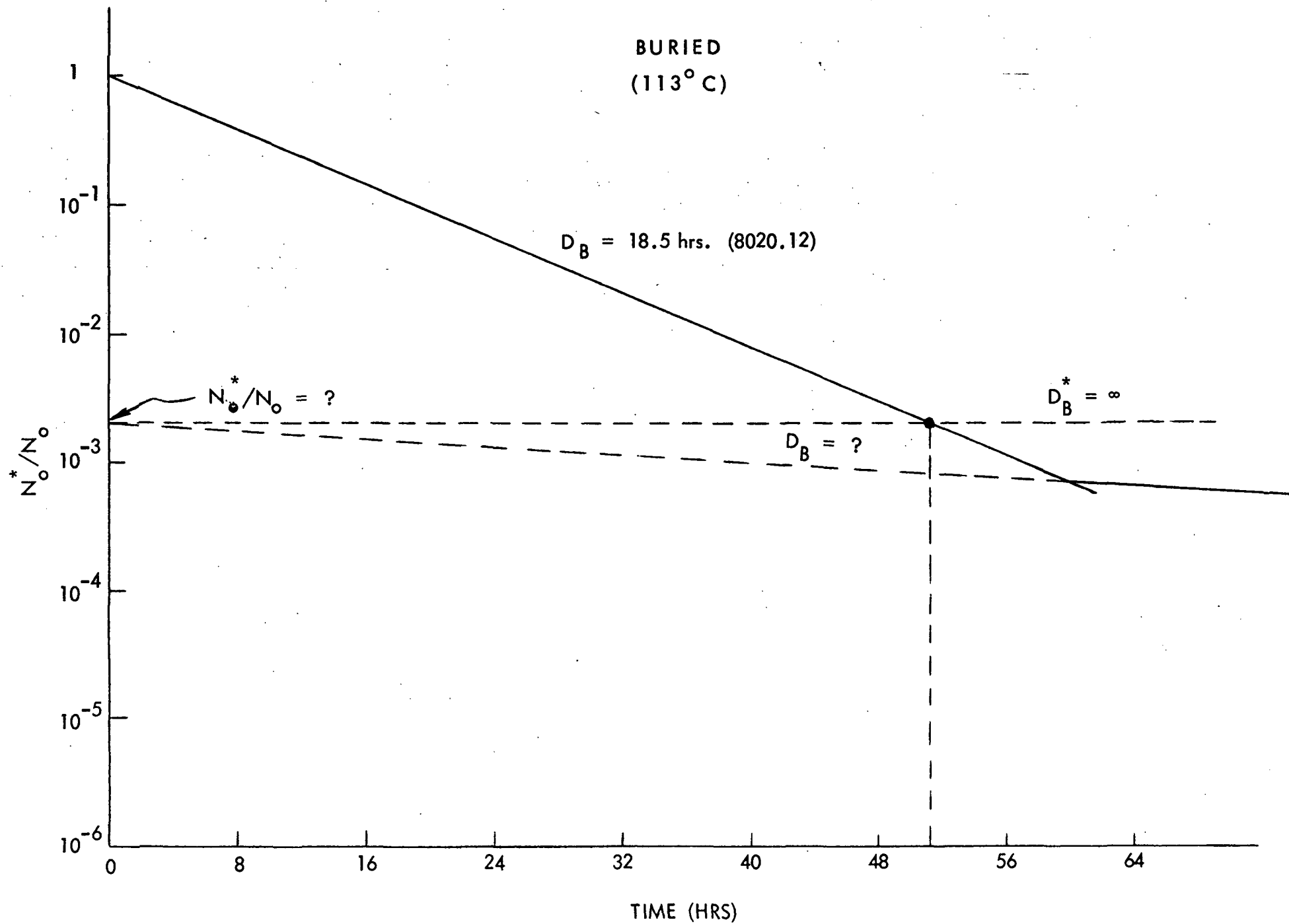
D<sub>8</sub> - Surface Heat Resistance



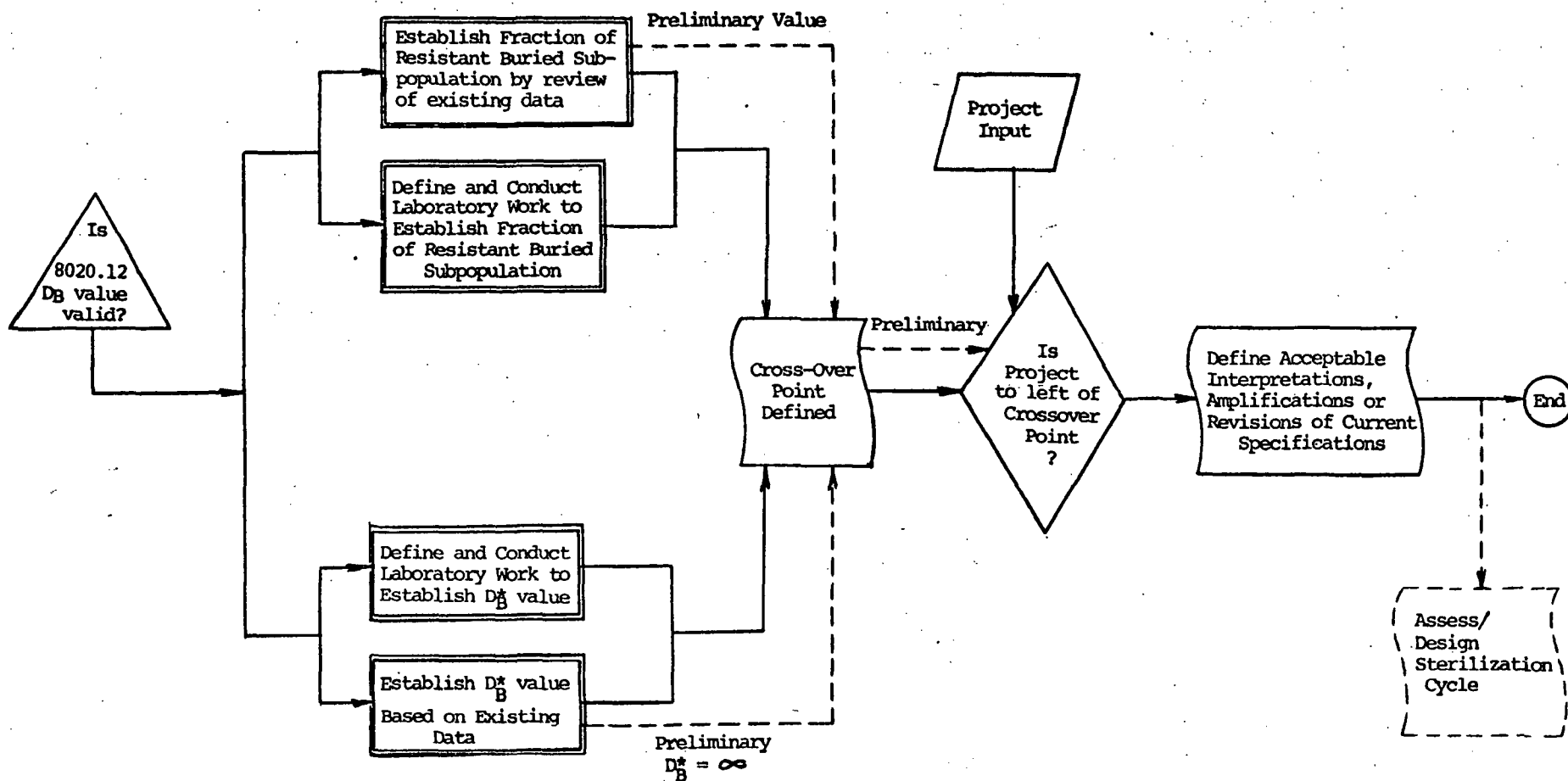


$D_m$  - Mated Heat Resistance





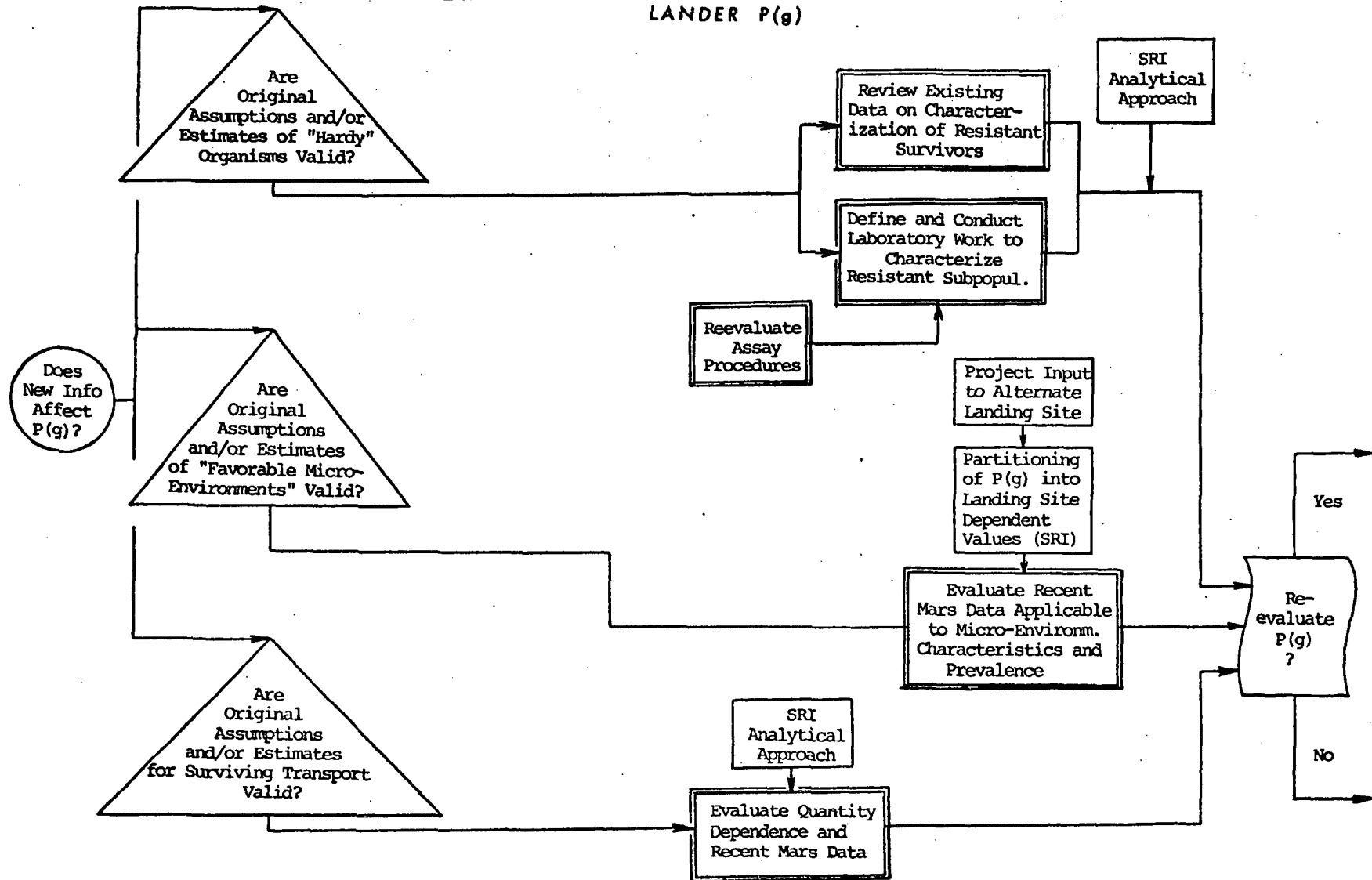
$D_B$  - Buried Heat Resistance



LANDER P(g)

	P (AREOPHILES)	P (HOSPITABLE MICROENVIRONMENT)	P (VIABLE TRANSPORT IN ADEQUATE NUMBERS)	P (g)
CURRENT  VALUES	$3 \times 10^{-4} - 10^{-2}$  ( $6.3 \times 10^{-3}$ )	$10^{-2} - 1$  ( $6.3 \times 10^{-2}$ )	$10^{-3} - 10^{-2}$  ( $2.5 \times 10^{-3}$ )	$3 \times 10^{-9}$ to $10^{-4}$  ( $10^{-6}$ )
NEW  INFORMATION	— SURVIVORS COME FROM A SMALL SUB- POPULATION	— PARTITIONING OF P(g) INTO LANDING SITE DEPENDENT VALUES (SRI)  — LANDING SITE CONSIDERATIONS  — MARINER 9 DATA	— NUMBER OF SURVI- VORS SMALL  — MARINER 9 DATA	?

# LANDER P(g)





## IMMEDIATE CONSIDERATIONS

1.  $D_s^*$ ,  $[N_o^*/N_o]_s$

Are preliminary values derived by Exotech usable?

$$(D_s^* = 25 \text{ hrs @ } 113^\circ \text{C}, [N_o^*/N_o]_s = 2.5 \times 10^{-3})$$

2.  $[N_o^*/N_o]_m$

What is an acceptable preliminary value?

Is the same value as for surfaces reasonable?

3.  $[N_o^*/N_o]_b$

What is an acceptable preliminary value?

Is the same value as for surfaces reasonable?

4. Lander  $P(g)$

Are there sufficient new inputs (see chart) to justify a re-evaluation of  $P(g)$  for landers?